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Indian Standard

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पर्वतीय भूभाग के भू-स्खलन आपदा के जोखिम मूल्यांकन का मानचित्र बनाना — दिशानिर्देश

Preparation of Landslide Risk Assessment Maps in Mountainous Terrains — Guidelines

ICS 07.040

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October 2020 **Price Group 8**

Hill Area Development Engineering Sectional Committee, CED 56

FOREWORD

This Indian Standard was adopted by the Bureau of Indian Standards, after the draft finalized by the Hill Area Development Engineering Sectional Committee, had been approved by the Civil Engineering Division Council.

Landslides are considered as one of the important natural hazards in hilly terrains. Their incidences have been on the increase in the recent time due to unplanned construction activities. Civil infrastructures and human population are affected whenever landslides occur in urbanized areas of hills.

Risk refers to the consequence or the nature of damage likely to be caused if the failure occurs. The damage may be direct in the form of loss of life and injuries and/or loss of land and properties or indirect, such as disruption of communication route and power line. The extent of damage is dependent on the existing land use pattern of the area and the density of population. The risk is basically dependent on hazard probability and the damage potential. Landslide risk assessment maps help to formulate a risk management programme by identifying the potential high risk areas. This standard provides guidelines indicating systematic procedures for preparing risk assessment maps and their utility.

The composition of the Committee responsible for the formulation of this standard is given in Annex A.

For the purpose of deciding whether a particular requirement of this standard is complied with the final value, observed or calculated, expressing the result of a test or analysis shall be rounded off in accordance with IS 2 : 1960 'Rule for rounding off numerical values (*revised*)'. The number of significant places retained in the rounded off value should be same as that of the specified value in this standard.

Indian Standard

PREPARATION OF LANDSLIDE RISK ASSESSMENT MAPS IN MOUNTAINOUS TERRAINS — GUIDELINES

1 SCOPE

This standard covers guidelines for preparation of landslide risk assessment (LRA) map on scale of 1 : 25 000 to 1 : 50 000.

NOTE — The LRA map will be prepared only after preparation of Landslide hazard zonation (LHZ) map on the same scale following IS 14496 (Part 2).

2 REFERENCES

The following standards contain provisions which through reference in this text, constitute provision of this standard. At the time of publication, the editions indicated were valid. All standards are subject to revision, and parties to agreements based on this standard are encouraged to investigate the possibility of applying the most recent editions of the standards indicated below:

IS No.	*Title*
7422	Symbols and abbreviations for use in geological maps, sections and subsurface exploratory logs
(Part 1) : 1974	Abbreviations
(Part 2) : 1974	Igneous rocks
(Part 3) : 1974	Sedimentary rocks
(Part 4) : 1985	Metamorphic rocks
(Part 5) : 1992	Line symbols for formation contacts and structural features
13365 (Part 3) : 1997	Quantitative classification system of rock mess — Guidelines: Part 3 Determination of slope mass rating
14458 (Part 1) : 1998	Retaining wall for hill area — Guidelines
(Part 2) : 1997	Design of retaining/breast walls
(Part 3) : 1998	Construction of dry stone walls
(Part 4) : 2018	Construction of banded dry stone masonry walls
(Part 5) : 2018	Construction of cement stone masonry walls
14496 (Part 2) : 1998	Guidelines for preparation of landslide hazard zonation maps in mountains terrains: Part 2 Macro–zonation
14680 : 1999	Landslide control — Guidelines

3 CONCEPT OF DANGER, HAZARD AND RISK

For effective landslide investigations, mapping is the basic requirement. Landslide mapping can be carried out based on different themes like ‘danger’, ‘hazard’ and ‘risk’.

3.1 Danger

Danger refers to an existing natural phenomenon, such as creep or it can be a potential one such as rock fall. The classification or description may be done based on site condition. This characterization does not include any forecasting of the events.

3.2 Hazard

The hazard refers to a probability of occurrence of a landslide danger. The period of time may be indicated in relative terms for different types of hazards. For example, in a predicted high hazard slope, the landslide may occur early as compared to a moderate hazard slope. The hazard maps can be prepared on regional scales (1 : 25 000 - 50 000) or on semi-regional scales (1 : 1 0 000 - 15 000) or on detailed scales (1 : 1 000 - 2 000) depending upon the requirements. While the studies on regional scales and semi-regional scales are generally based on empirical approaches, the detailed studies are based on analytical methods. In regional and semi-regional studies, the landslide hazards are rapidly assessed and hence, larger areas can be covered in short durations. These methods are based on causative factors of slope instabilities and help to identify hazard prone areas for further detailed studies. The analytical methods are employed in detailed studies for different segments of a slope. These studies determine the status of stability in terms of factor of safety taking into consideration the total shear stresses acting on the slope and the shear strength of the slope materials.

3.3 Risk(R)

Risk refers to consequence or the nature of damage likely to be caused if the failure occurs. The damage may be direct in the form of loss of life and injuries and/or loss of land and properties or indirect, such as disruption of communication route, power transmission line, etc. The extent of damage is dependent on the existing land use pattern of the area likely to be affected and the population. For example, a major landslide in a remote area may cause less damage as compared to a smaller landslide in a thickly populated area. Hence, risk is a function of hazard probability and the damage potential, as given below:

$$R = \text{f (HP, DP)}$$

where

HP = hazard probability, and

DP = damage potential.

Risk assessment may be undertaken after evaluating the nature of hazard of a slope and its damage potential (*see* Fig. 1). The required data related to hazard can be obtained from landslide hazard zonation map and the damage potential can be obtained from Tables 1 and 3.

4 LANDSLIDE HAZARD ZONATION

Landslide hazard zonation (LHZ) refers to division of land surface of the study area (*see* Fig. 2) into zones of varying degree of stability based on an estimated significance of causative factors in inducing the instability. The LHZ maps are prepared on regional scales of 1 : 25 000 - 50 000. The hazard probability (HP) can be obtained from LHZ maps.

The LHZ map of an area is prepared on a facet map, which is in turn derived from the topographical map [*see* IS 14496 (Part 2)]. A facet is a part of hill slope which has more or less similar slope characteristics, such as consistent slope direction and inclination (*see* Fig. 3). The LHZ maps can be prepared using a numerical ratings scheme called landslide hazard evaluation factor (LHEF) rating scheme. The preparation of LHZ map follows a sequential procedure of preparing various thematic maps namely lithological map (*see* Fig. 4), structural map (*see* Fig. 5), slope morphometry map (*see* Fig. 6), relative relief map (*see* Fig. 7), land use land cover map (*see* Fig. 8) and hydrogeological map (*see* Fig. 9) in addition to a location map (*see* Fig. 2) of area. With the help of these thematic maps, the total estimated hazard (TEHD) is calculated and the LHZ map (*see* Fig. 10) prepared. For more details of landslide hazard zonation procedure, *see* IS 14496 (Part 2).

5 RISK ASSESSMENT

Risk assessment refers to an estimation of the extent of damage likely to result if the landslide occurs. The damage may occur on the same slope facet where the hazard exists or it may extend into the adjoining facets. The damage may be classified broadly into two categories:

a) loss of life and injuries, and
b) loss of land and properties.

The former may be significant when the landslide occurs all of a sudden and in a short time. However, the damage to land and/or property is unavoidable in all landslide events. Since both categories of damage have entirely different consequences, they have to be evaluated differently for the purposes of risk assessment. Such studies may have more relevance in cases of high hazard (HH) and very high hazard (VHH) slope facets. Since risk is a function of hazard probability and damage potential, the damage potential has to be evaluated in terms of population suffering from loss of life and/or injuries as well as loss of land and properties.

5.1 Risk Assessment for Loss of Life and/or Injury

The damage due to loss of life and/or injury assumes greater significance compared to loss of land and property. However, it may be difficult to collect the census of persons for including in the risk assessment. Moreover, the number may often vary greatly within short durations. Instead, it is very convenient and logical to use the number of dwellings which can be assessed during site visits. The history of damages may also be assessed on the basis of experience. The damage potential of human dwellings may be estimated from the Table 1.

Table 1 Damage Potential (DP) for Human Dwellings

(*Clause* 5.1)

Sl No. (1)	No. of Dwellings Likely to be Damaged (2)	Type of DP (3)
i)	<2	VLDP
ii)	2-5	LDP
iii)	5-10	MDP
iv)	10-50	HDP
v)	>50	VHDP

NOTE — VLDP – Very Low Damage Potential, LDP – Low Damage Potential, MDP – Moderate Damage Potential, HDP – High Damage Potential, VHDP – Very High Damage Potential

5.2 Relationship of Hazard Probability and Damage Potential for Human Dwellings

From the landslide hazard zonation (LHZ) map, the hazard probability (HP) of slope facets can be obtained. The slope facets showing high hazard (HH) and very high hazard (VHH) are more important for

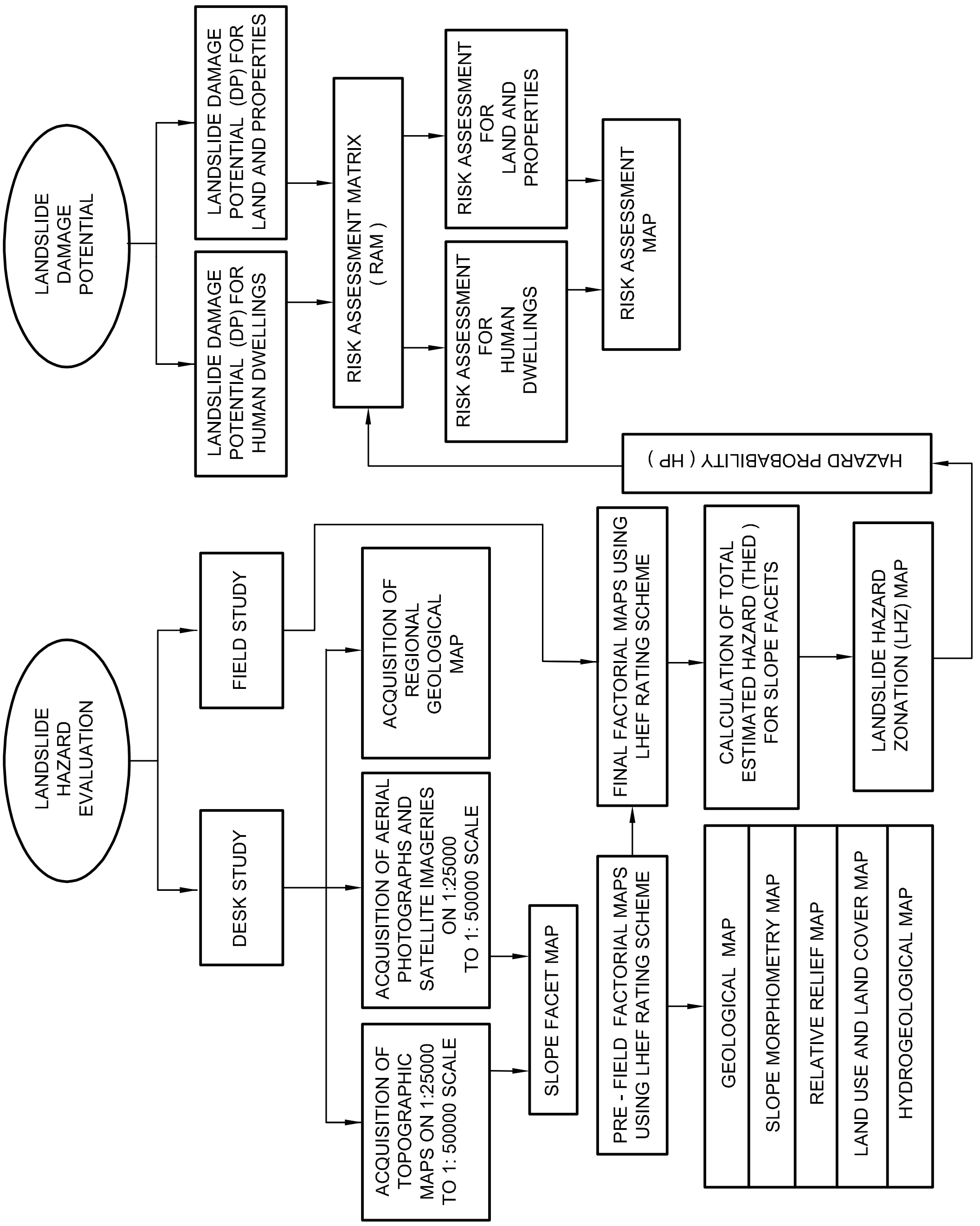

LANDSLIDE HAZARD EVALUATION
DESK STUDY
FIELD STUDY
ACQUISITION OF TOPOGRAPHIC MAPS ON 1:25000 TO 1: 50000 SCALE
ACQUISITION OF AERIAL PHOTOGRAPHS AND SATELLITE IMAGERIES ON 1:25000 TO 1: 50000 SCALE
ACQUISITION OF REGIONAL GEOLOGICAL MAP
SLOPE FACET MAP
PRE - FIELD FACTORIAL MAPS USING LHEF RATING SCHEME
GEOLOGICAL MAP
SLOPE MORPHOMETRY MAP
RELATIVE RELIEF MAP
LAND USE AND LAND COVER MAP
HYDROGEOLOGICAL MAP
FINAL FACTORIAL MAPS USING LHEF RATING SCHEME
CALCULATION OF TOTAL ESTIMATED HAZARD (THED) FOR SLOPE FACETS
LANDSLIDE HAZARD ZONATION (LHZ) MAP
HAZARD PROBABILITY (HP)
LANDSLIDE DAMAGE POTENTIAL
LANDSLIDE DAMAGE POTENTIAL (DP) FOR HUMAN DWELLINGS
LANDSLIDE DAMAGE POTENTIAL (DP) FOR LAND AND PROPERTIES
RISK ASSESSMENT MATRIX (RAM)
RISK ASSESSMENT FOR HUMAN DWELLINGS
RISK ASSESSMENT FOR LAND AND PROPERTIES
RISK ASSESSMENT MAP

Fig. 1 General Procedure for Risk Assessment (RA) Mapping

risk assessment. Hence they are initially taken up for detailed risk assessment by identifying the nature of hazards as well as possible run out area. Later the other hazard zones are also studied and risk assessed. Since the damage potential (DP) may have varying impacts depending on the hazard potential of a slope facet, their relationship may be shown in the form of a risk assessment matrix (RAM) (*see* Table 2).

Table 2 Risk Assessment Matrix (RAM) for Human Dwellings

(*Clause* 5.2)

Sl No.	Damage Potential (DP)	Hazard Probability (HP)				
		VLHP	LHP	MHP	HHP	VHHP
(1)	(2)	(3)	(4)	(5)	(6)	(7)
i)	VLDP	VLR	VLR	LR	LR	LR
ii)	LDP	VLR	LR	LR	MR	MR
iii)	MDP	LR	LR	MR	HR	HR
iv)	HDP	LR	LR	HR	VHR	VHR
v)	VHDP	LR	LR	HR	VHR	VHR

NOTE — VLR- Very low risk; LR- Low risk; MR- Moderate risk; HR- High risk; VHR-Very high risk.

5.3 Risk Assessment for Land and Property

When a landslide occurs, the risk to land is unavoidable. This may be a barren land, agricultural land or forest. Property likely to be affected by landslides includes residential areas, transport routes, industrial and business premises, schools parks and other such features.

Since properties are located on the land surface likely to be affected, they can be simply shown with different symbols. Hence, a damage potential status is proposed for different categories of land (*see* Table 3). Here the barren land and the very sparsely vegetated land have been considered as the same.

The agricultural land has been grouped together with moderately vegetated land. Agricultural land may also be shown with some additional symbol on the risk map (*see* Fig. 11)

Table 3 Damage Potential for Land Categories

(*Clauses* 3.3 *and* 5.3)

Sl No.	Land Category	Damage Potential (DP)
(1)	(2)	(3)
i)	Barren/very sparsely vegetated	VLDP
ii)	Sparsely vegetated	LDP
iii)	Moderately vegetated/agricultural land	MDP
iv)	Thickly vegetated	HDP
v)	Very thickly vegetated	VHDP

5.4 Relationship of Hazard Probability and Damage Potential for Land

The landslide hazard zonation (LHZ) map may show the distribution of hazard prone areas. In order to show the relation between the hazard probability and damage potential for land, a risk assessment matrix (RAM) has been proposed (*see* Table 4).

Table 4 Risk Assessment Matrix for Land Categories

(*Clause* 5.4)

Sl No.	Damage Potential (DP)	Hazard Probability (HP)				
		VLHP	LHP	MHP	HHP	VHHP
(1)	(2)	(3)	(4)	(5)	(6)	(7)
i)	VLDP	VLR	VLR	LR	LR	LR
ii)	LDP	VLR	VLR	LR	MR	MR
iii)	MDP	LR	LR	MR	HR	HR
iv)	HDP	LR	LR	HR	HR	VHR
v)	VHDP	LR	LR	HR	VHR	VHR

6 IMPORTANT CONSIDERATIONS IN PREPARATION OF RISK ASSESSMENT MAPS

The preparation of a risk assessment (RA) map may be carried out immediately after the preparation of the LHZ map or after carrying out the detailed study of the HH and VHH facets for preparing a reliable RA map (*see* Fig. 1). A quick study of the HH and VHH facets will help to locate the boundaries of the risk categories as well as to understand the nature of causative factors and types of failure. Moreover, the land use and land cover map prepared during LHZ mapping, in addition to collecting data pertaining to human dwellings and other structures, will help greatly in a judicial risk assessment.

The boundaries of the risk categories may be within the same slope facet in which the hazard exists or partly within and partly outside. For example, if a human settlement is located on a stable slope below a steep cliff, the risk due to the unstable cliff face may lie mostly outside the facet. Hence the risk assessment map may have different boundaries compared to LHZ maps.

The factors given in **6.1** to **6.3** are mainly considered while marking the boundary of the risk categories.

6.1 Topography of the Area, Particularly the Slope Facet in which the Hazard Exists and the Adjoining Facets

If the slopes are steep, the risk may involve the adjoining slope facets particularly at lower levels. Tension cracks likely to be caused by a landslide may affect the adjoining slopes at higher levels due to progressive failure of the slope.

6.2 Nature of Failure

Flows such as debris flow are capable of penetrating much deeper into the adjoining slopes at lower levels. Rock falls may affect the adjoining slopes. Planar, wedge and rotational failures depending on the size, may affect the peripheral regions of the adjoining facets. However, before the actual failure, the effects of distressing are often seen on the slopes.

6.3 Geological Factors Controlling the Nature of Failure

In rock slides, the disposition of the critical discontinuities, the nature of weathering, type of rocks and extent of fractionation play important roles in defining the boundary of the risk zones.

Maps can show the boundaries of different categories of risk pertaining to both the land and the human dwellings. In addition, the other engineering structures and properties may also be indicated with different symbols (*see* Fig 11).

Risk assessment maps may also be prepared on semi-regional scales (1 : 10 000 - 15 000) or detailed scales (1 : 1 000 - 2 000) for specific purposes, such as risk maps for linear structures like roads or railway lines or canals. In such cases, different damage potential criteria may be preferred, as shown in Table 5. If required, even the roads can be classified into various types and the damage potential worked out separately for each type of road. For an evaluation of hazard along the road, slope mass rating (SMR) technique as indicated in IS13365 (Part 3) can be used and it can be combined with damage potential to prepare the risk map.

Table 5 Damage Potential (DP) for Roads and Rail Lines

(*Clause* 6.3)

Sl No. (1)	Length of Damage, m (2)	Status of Damage Potential (3)
i)	<50	DLDP
ii)	51-100	LDP
iii)	101-200	MDP
iv)	201-500	HDP
v)	>500	VHDP

7 GENERAL PROCEDURE FOR RISK ASSESSMENT

7.1 The risk assessment involves two important activities, namely (a) landslide hazard evaluation, and (b) evaluation of damage potential. The landslide hazards evaluation is carried out following two important phases of activities namely desk study and field study.

During desk study already available topo sheets, aerial photographs, satellite imageries and geological maps are collected. These are to prepare a series of prefilled maps which could be validated during field study.

During field study the prefilled maps are checked in the field and updated on that basis a series of factorial maps are prepared for calculating total estimated hazard (TEHD) facets wise.

7.2 The damage potential (DP) can be assesses for loss of life and injuries as well as for land and properties using respective tables given in this standard.

7.3 From the landslide hazard zonation maps, hazard probability (HP) can be estimated and damage potential (DP) can be assessed from the respective tables given in this standard.

7.4 Risk Assessment Matrix (RAM) is a combination of hazard probability (HP) and damage potential (DP). Risk assessment for both human dwellings and land and properties can be evaluated from the RAM. Risk assessment map can be prepared after the risk assessment for both human dwellings and land and properties (*see* Fig 1).

8 PRESENTATION OF RESULTS

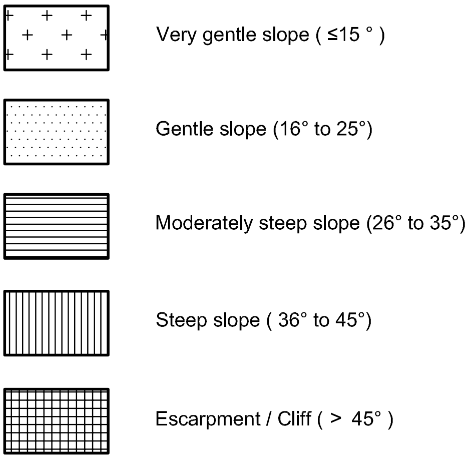
8.1 The results shall be presented in the form of maps. The terrain evaluation maps shall be prepared in the first stage, showing the nature of facet-wise distribution of parameters. The terrain evaluation maps shall be superimposed and total estimated hazard (TEHD) calculated for individual facets.

A macro-zonation landslide risk map shall be prepared based on facet wise distribution of TEHD values. From the landslide hazard zonation (LHZ) map, hazard probability (HP) can be estimated.

8.2 Symbols for Lithological and Structural Maps

The symbols and abbreviations are given in IS 7422 (Parts 1 to 5) shall be used for the lithological and structural maps.

8.3 Suggested Symbols for Slope Morphometry Map


Very gentle slope (≤15 °)
Gentle slope (16° to 25°)
Moderately steep slope (26° to 35°)
Steep slope (36° to 45°)
Escarpment / Cliff (> 45°)

8.4 Suggested Symbols for Relative Relief Map

░	Low Relief
▤	Moderate Relief
▥	High Relief

8.5 Suggested Symbols for Land Use and Land Cover Map

+	Agricultural Land / Populated flat land
░	Thickly Vegetated Forest
▤	Moderately vegetated forest area
▥	Sparsely vegetated area with lesser ground
▦	Barren land

8.6 Suggested Symbols for Hydrogeological Conditions Map

+	Dry
░	Damp
▤	Wet
▥	Dripping
▦	Flowing

8.7 Suggested Symbols for LHZ Map

+	Very low hazard (VLH)
░	Low hazard (LH)
▤	Moderate hazard (MH)
▥	High hazard (HH)
▦	Very high hazard (VHH)

8.8 Suggested Symbols for Landslide Risk Map

+	Very low risk (VLR)
░	Low risk (LR)
▤	Moderate risk (MR)
▥	High risk (HR)
▦	Very high risk (VHR)

9 INTERPRETATION

The high risk (HR) and very high risk (VHR) require immediate attention for detailed study and implementation of control measures. The moderate risk (MR) may have some pockets of high risk zones which may be identified and suitably treated. The low risk (LR) and very low risk (VLR) are generally safe. In case of progressive failures, the boundaries will keep on expanding with time unless long term stabilization measures are implemented.

10 UTILITY OF RISK ASSESSMENT MAPS

Based on risk assessment map, risk management programmes can be planned to avoid a possible risk to the human population, land and properties including engineering structures. The high and very high risk areas are given top priority for such remedial/control measures. Immediate short-term measures, such as grading of slopes, proper drainage, retaining walls may be identified and implemented using IS 14458 (Parts 1 to 5) and IS 14680. Moreover, the long term measures, such as biotechnical stabilizations, maintenance of existing drainages, and provision of sub-surface drainages, anchors and additional catch water drains may also be planned.

11 REVISION OF RISK ASSESSMENT MAPS

Since damage potential is a variable parameter, risk assessment may also require modifications with time in any specific location. Similarly, human population may also show changing trend with time and subsequent change in ecological stresses. In addition natural events like major earthquake (greater than 5 on Richter's scale) close to study area, flood, cyclone, prolonged rainfall or cloud burst along with mining and constructional activities on large scale, as these incidences may trigger fresh landslides/slope instabilities in hilly areas. These parameters warrant suitable modifications from time to time

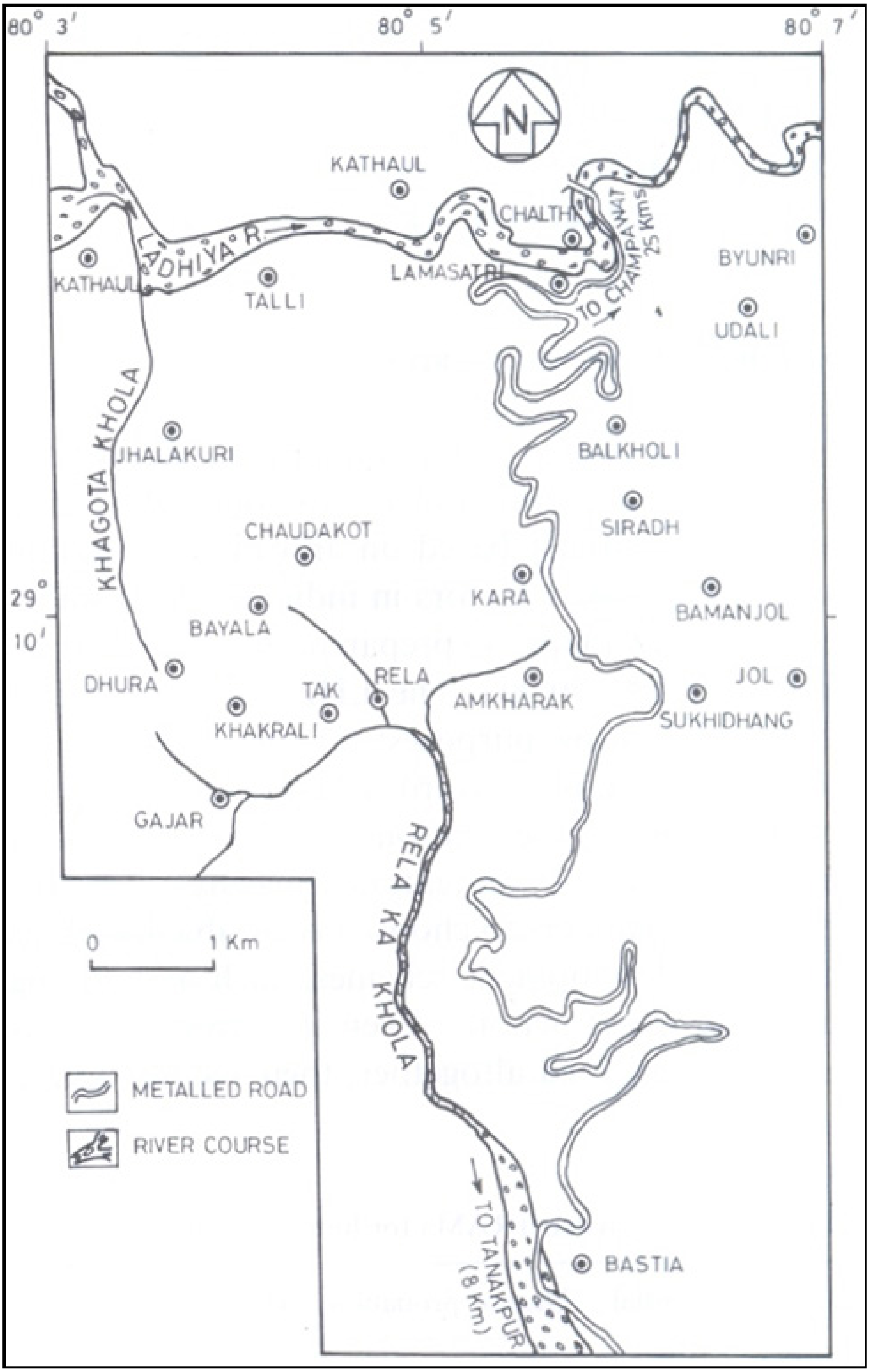


FIG. 2 TYPICAL LOCATION MAP OF THE STUDY AREA

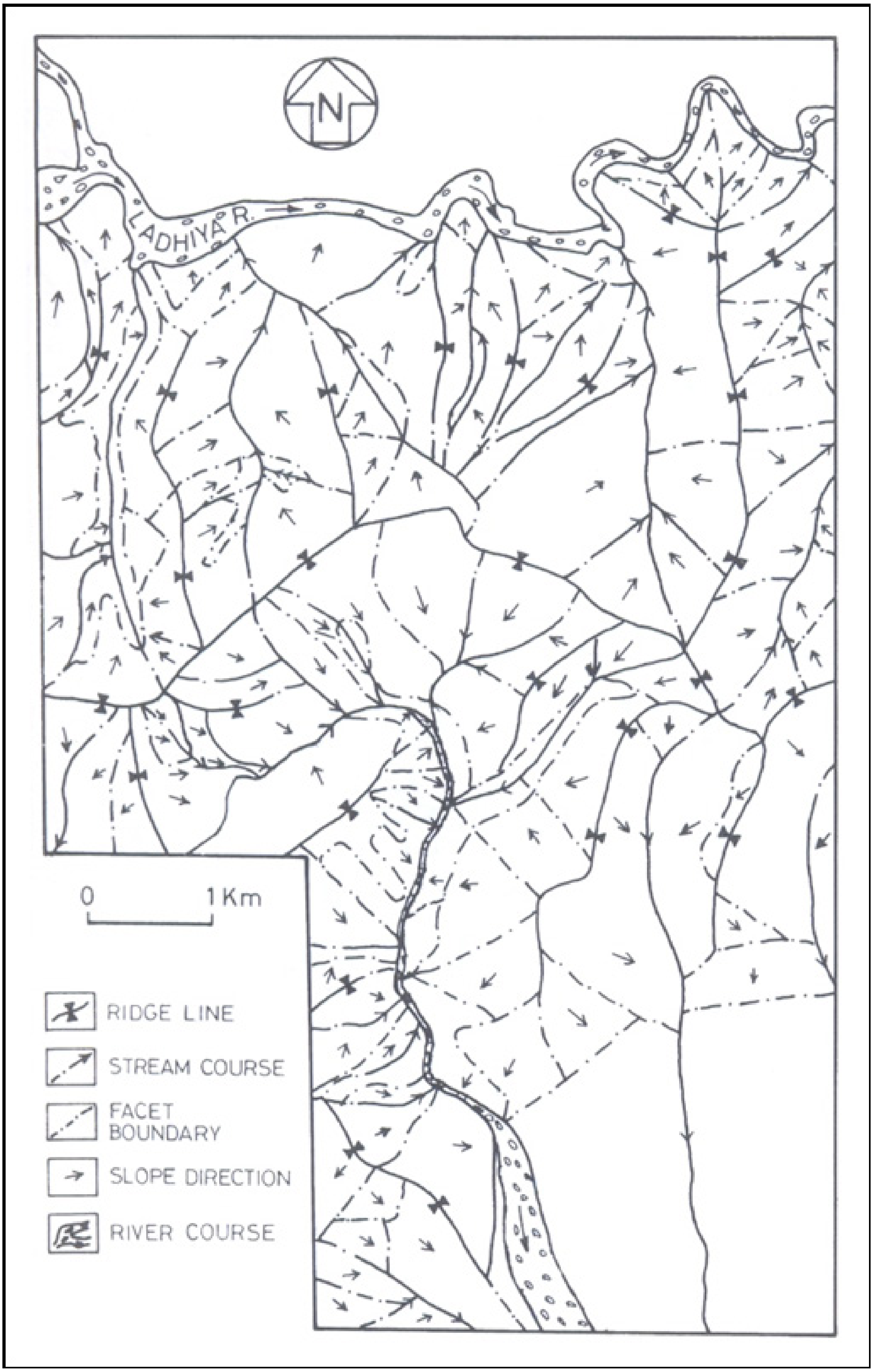


FIG. 3 TYPICAL SLOPE FACET MAP

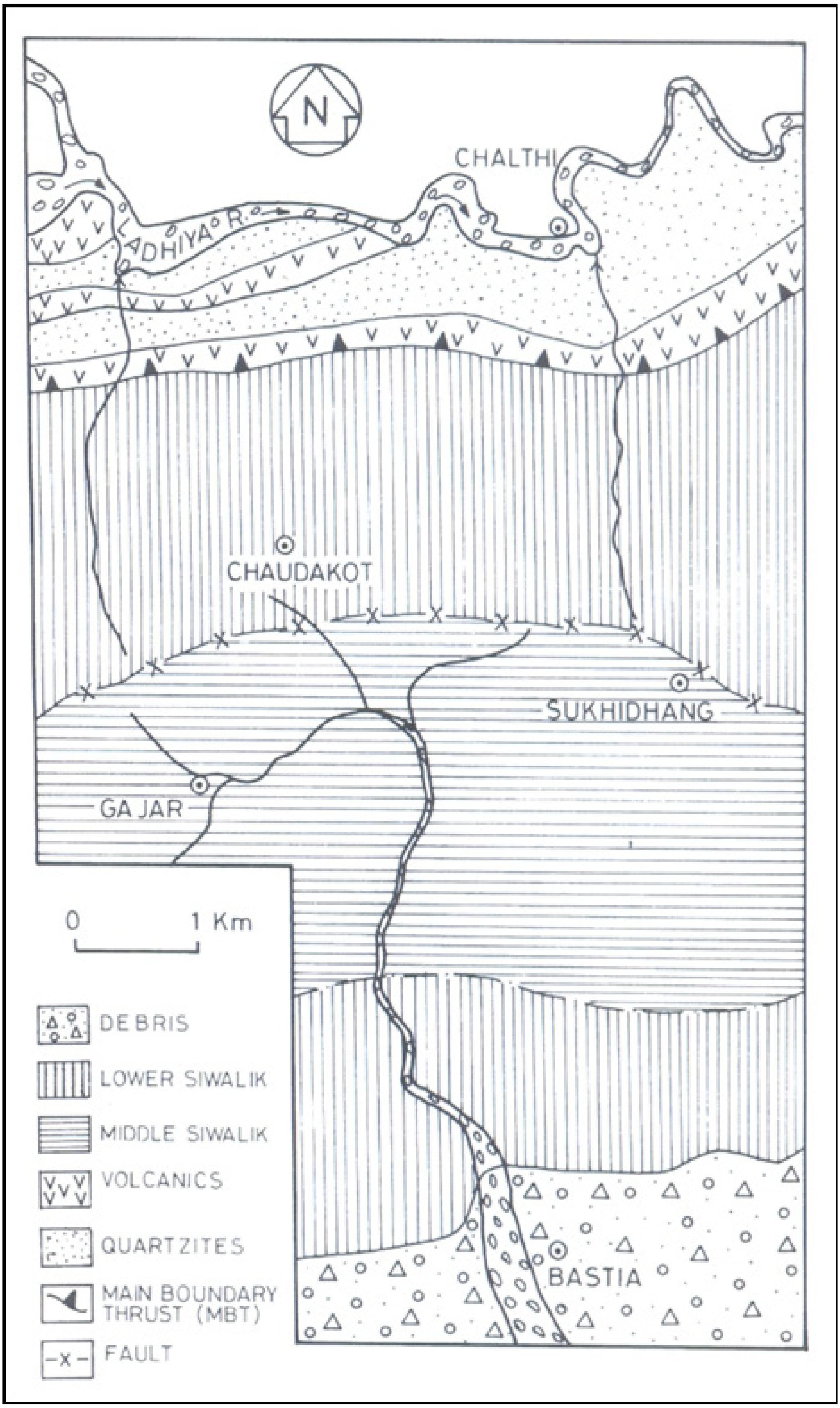


FIG. 4 TYPICAL LITHOLOGICAL MAP

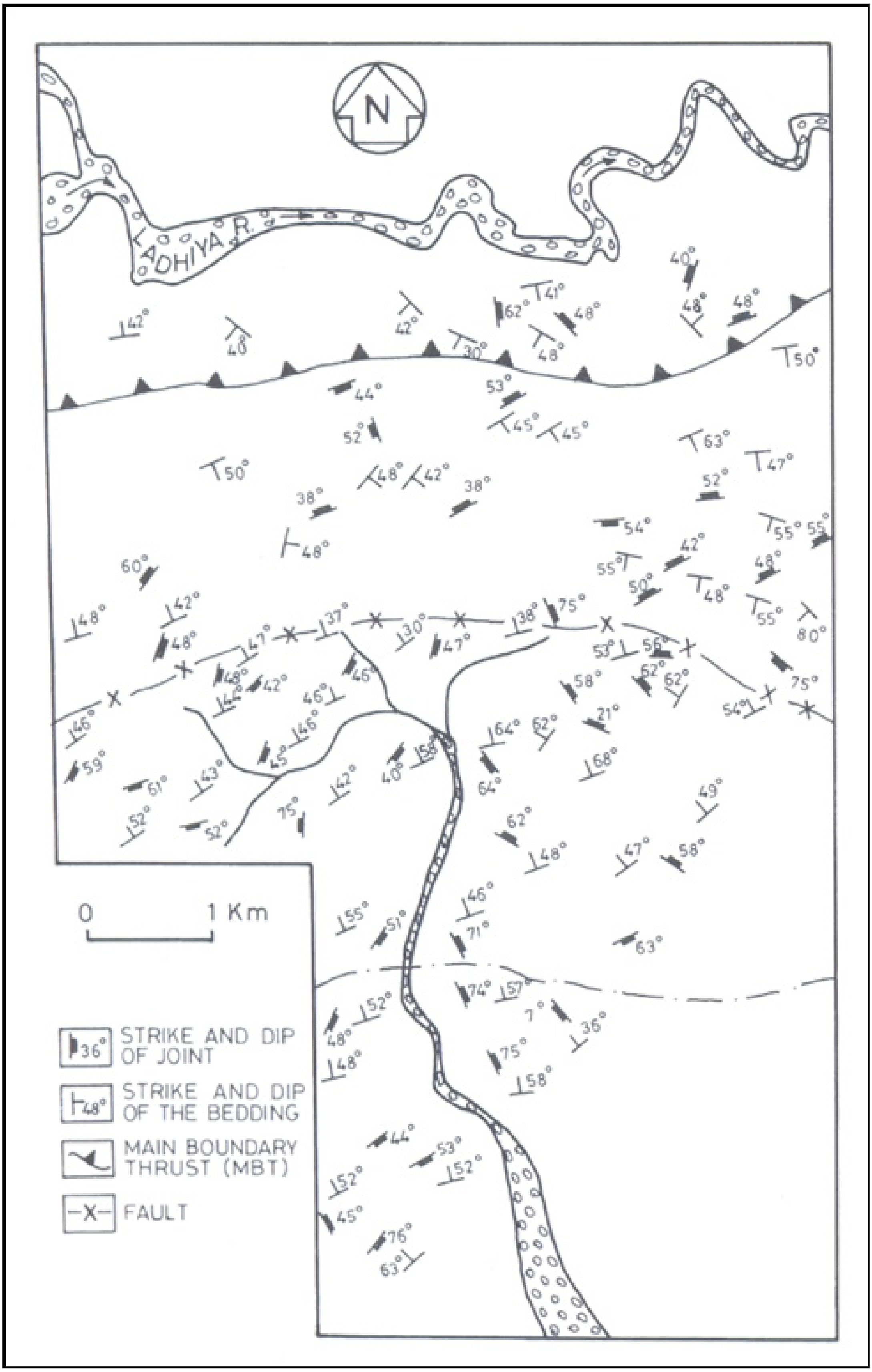


Fig. 5 Typical Structural Map

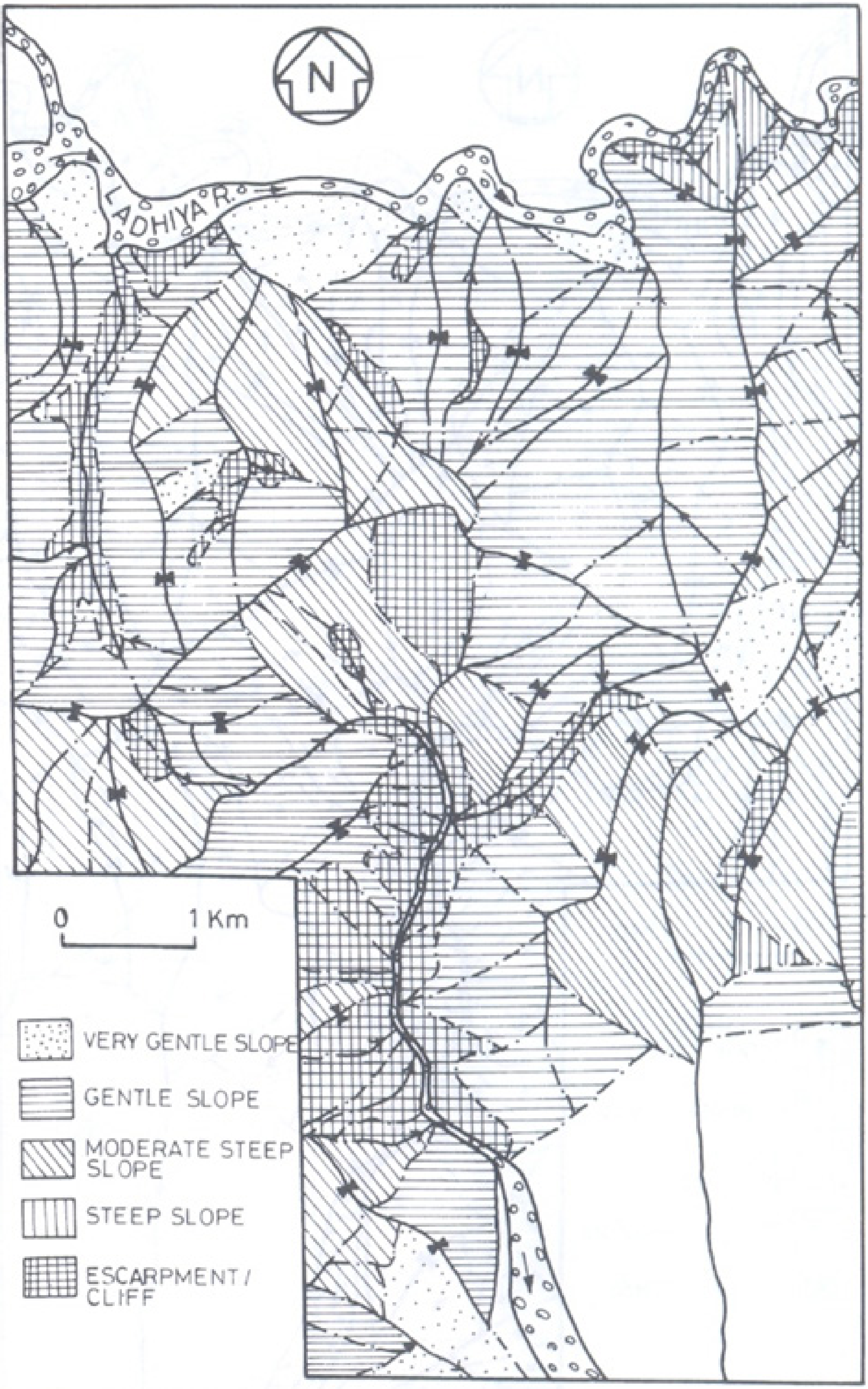


FIG. 6 TYPICAL SLOPE MORPHOMETRY MAP

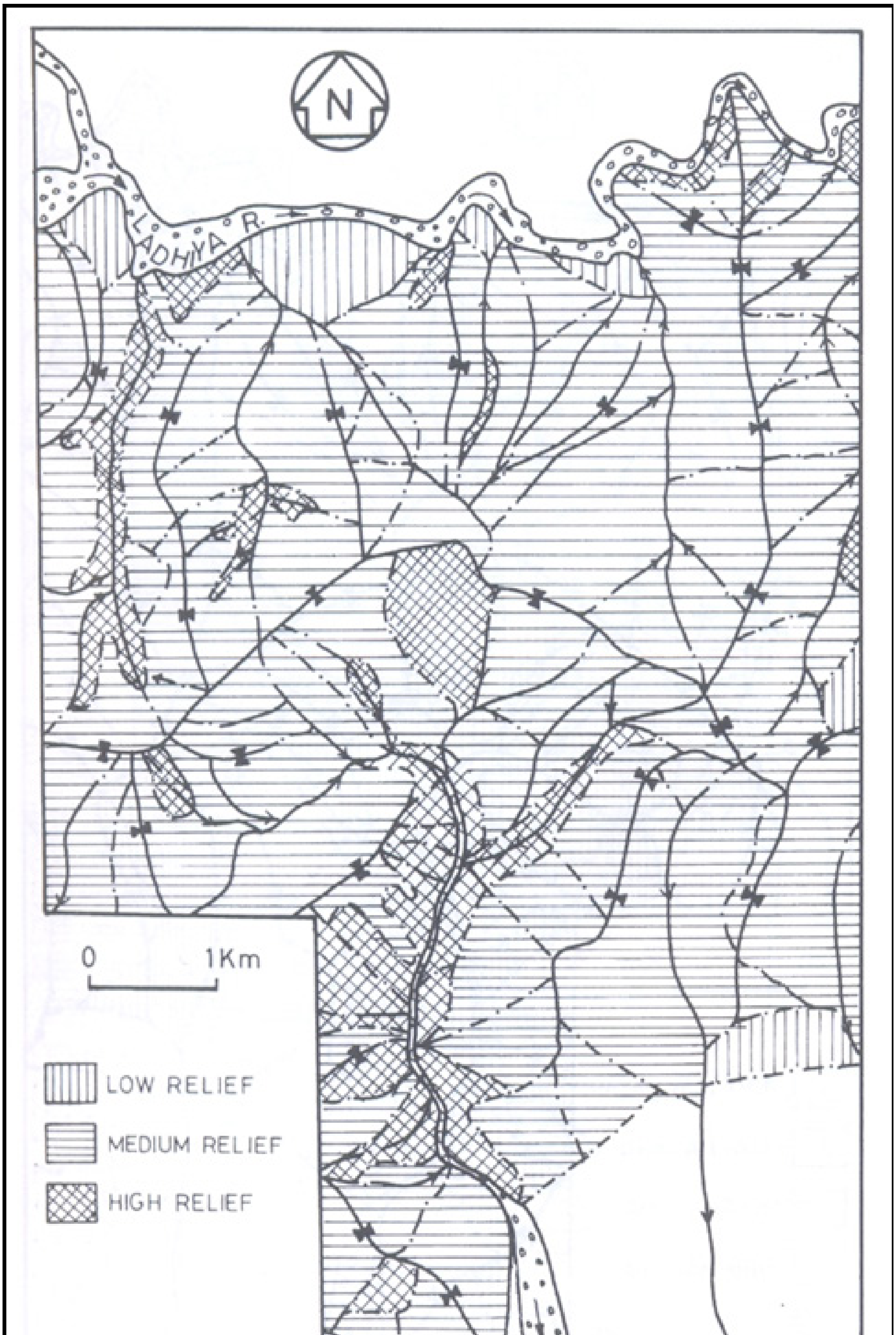


FIG. 7 TYPICAL RELATIVE RELIEF MAP

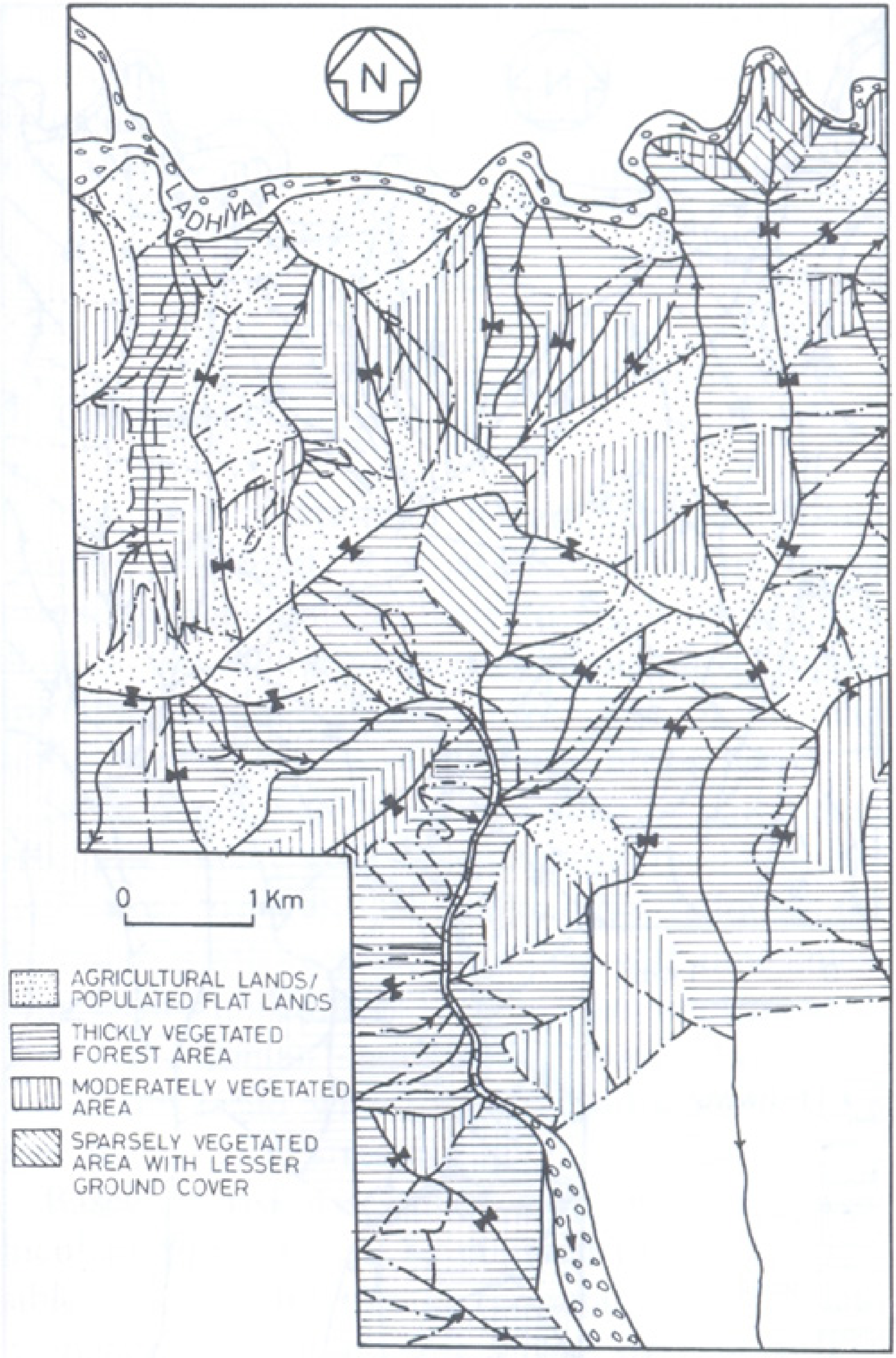

N
LADHIYA R.
0
1 Km
AGRICULTURAL LANDS/ POPULATED FLAT LANDS
THICKLY VEGETATED FOREST AREA
MODERATELY VEGETATED AREA
SPARSELY VEGETATED AREA WITH LESSER GROUND COVER

FIG. 8 TYPICAL LAND USE LAND COVER MAP

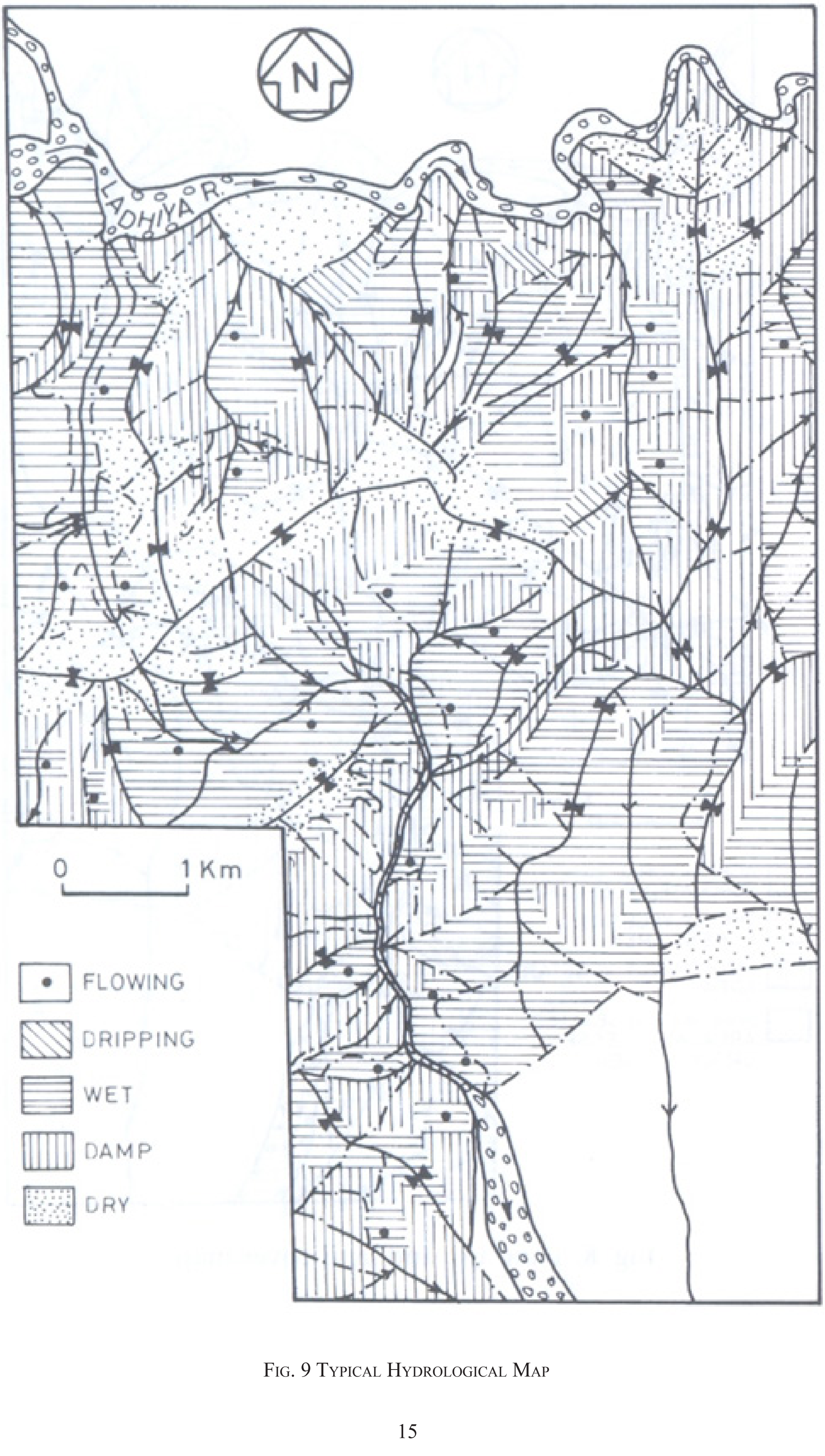


FIG. 9 TYPICAL HYDROLOGICAL MAP

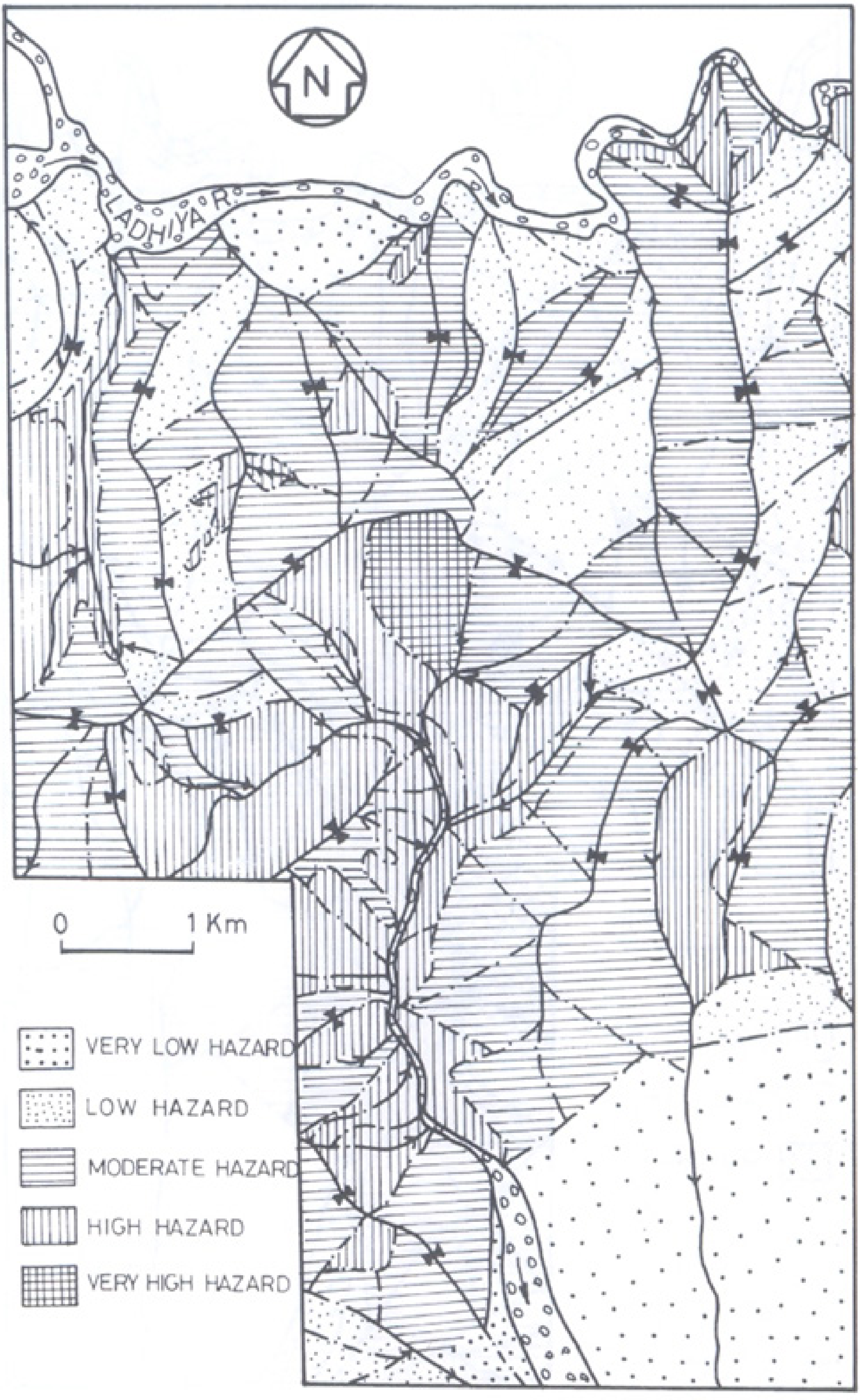


FIG. 10 TYPICAL LANDSLIDE HAZARD ZONATION MAP

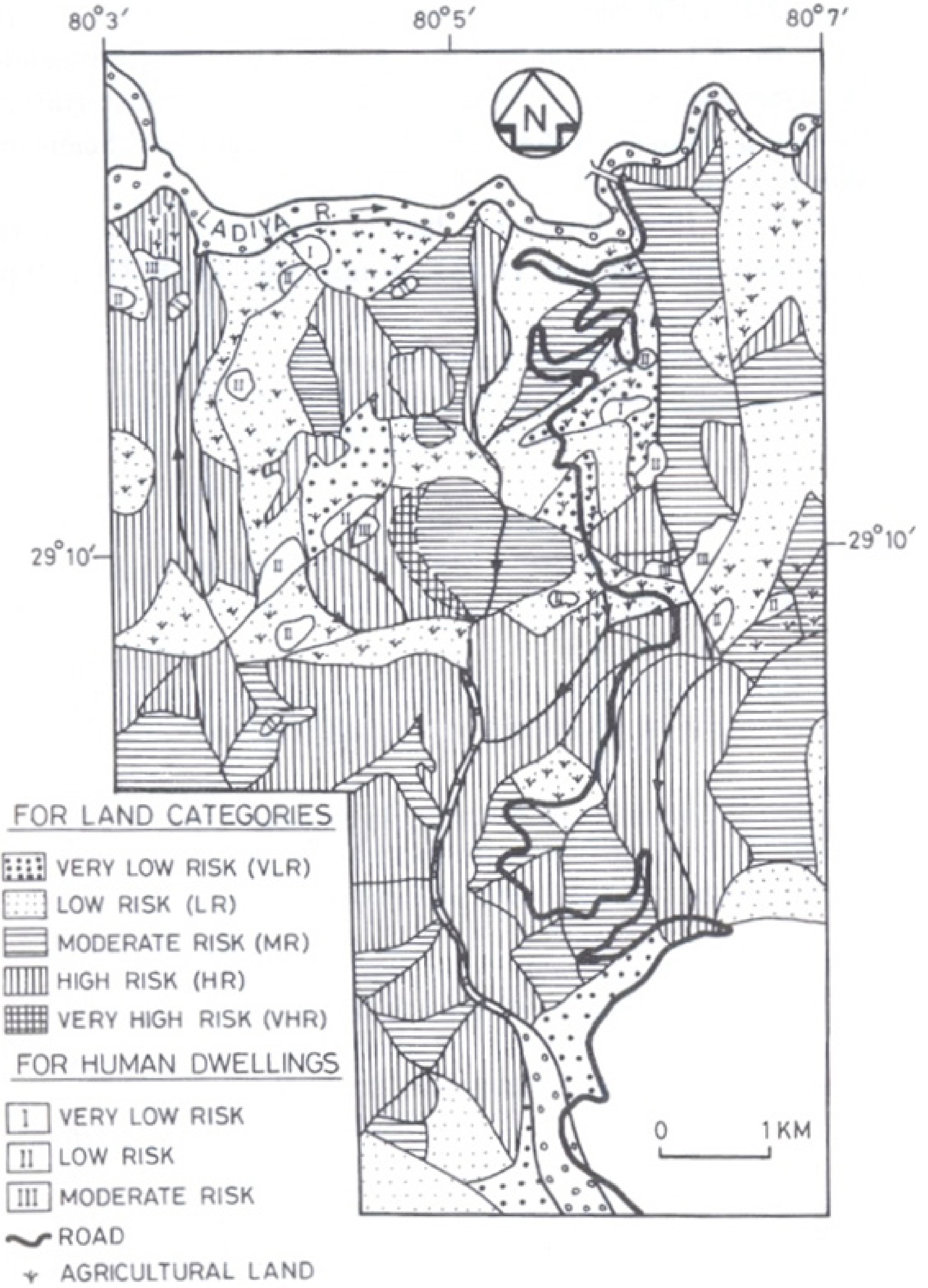


Fig. 11 Risk Assessment Map

ANNEX A

(*Foreword*)

COMMITTEE COMPOSTION

Hill Area Development Engineering Sectional Committee, CED 56

Organization	*Representative(s)*
In Personal Capacity (*H No-FFA, Block - G Priya Sudarsana Apts, Melur Road, Srirangam Tiruchirappalli, Tami Nadu*)	Dr R. Anbalagan (***Chairman***)
AIMIL Ltd, New Delhi	Sharique Khan Shri Aman Khullar (*Alternate*)
Border Roads Organization, New Delhi	Brig A. K. Das Lt Col Parikshit Mehra (*Alternate*)
Building Materials & Technology Promotion Council, New Delhi	Dr Shailesh Kumar Agarwal
Central Public Works Department, Shillong	Shri Sheo Prasad Singh Shri Prem Chand Mathur (*Alternate*)
Central Soil & Materials Research Station, New Delhi	Dr Manish Gupta Shri Hari Das (*Alternate*)
Central Water Commission, New Delhi	Director HCD (Nw&S)) Director (Sardar Sarovar) (*Alternate*)
CSIR - Central Building Research Institute, Roorkee	Shri Ashok Kumar Shri Ajai Chaurasia (*Alternate*)
CSIR - Central Institute of Mining & Fuel Research, Roorkee	Dr R. K. Goel Shri Anil Swarup (*Alternate*)
CSIR - Central Road Research Institute, New Delhi	Dr Kishor Kumar Dr Pankaj Gupta (*Alternate*)
Defence Terrain Research Laboratory/(DRDO), Delhi	Dr L. K. Sinha
Department of Science & Technology, Ministry of Science & Technology, New Delhi	Shri Bhoop Singh
G. B. Pant Institute of Himalayan Environment Development, Almora	Shri Kireet Kumar Shri Soukhin Tarafdar (*Alternate*)
Geological Survey of India, Kolkata	Shri M. S. Bodas Dr T. B. Goshal (*Alternate*)
Himalayan Environmental Studies & Conservation Organization, Dehradun	Dr Anil Joshi
Housing & Urban Development Corporation Ltd, New Delhi	Chairman & Managing Director
Indian Army Corps of Engineers, YOL CANTT	Brig Virender Singh Kattarya
Indian Institute of Remote Sensing, Dehradun	Dr P. K. Champati Ray Dr Ajanta Goswami (*Alternate*)
Indian Institute of Technology Roorkee, Roorkee	Dr M. N. Viladkar Dr Mahendra Singh (*Alternate*)
Indian Institute of Technology Bombay, Mumbai	Representative
Konkan Railway Corporation, Navi Mumbai	Shri Rajesh Agarwal

Organization	*Representative(s)*
Maccaferri Environmental Solutions Pvt Ltd, Gurugram	Shrimati Minimol Korulla Dr H. S. Mandal (*Alternate*)
Military Engineer Services, Engineer-in-Chief's Branch, Integrated HQ of Ministry of Defence, (Army), New Delhi	Shrimati Rivoo Mahendru Shri S. K. Mishra (*Alternate*)
National Centre for Seismology, New Delhi	Dr O. P. Mishra Dr H. S. Mandal (*Alternate*)
National Highway Authority of India, New Delhi	Dr Ram Kumar Shri R. P. Singh (*Alternate*)
National Hydroelectric Power Corporation Ltd, Hepali	Shri S. Murugappan
National Institute of Disaster Management, New Delhi	Representative
National Institute of Hydrology, Roorkee	Shri R. D. Singh Dr Sudhir Kumar (*Alternate*)
Rail Vikas Nigam Limited, New Delhi	Shri Sumit Jain
SJVN Limited, Shimla	Shri A. K. Chadha
Snow Avalanche Study and Establishment, Chandigarh	Col P. Mathur
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